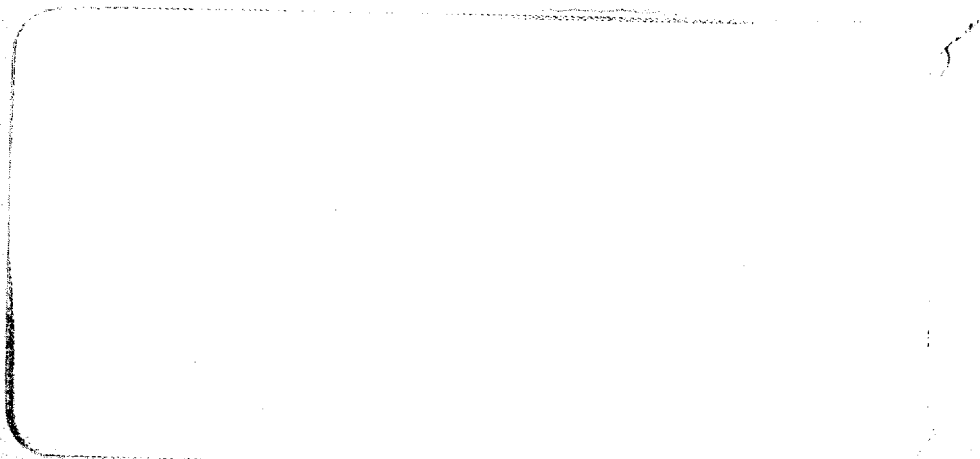


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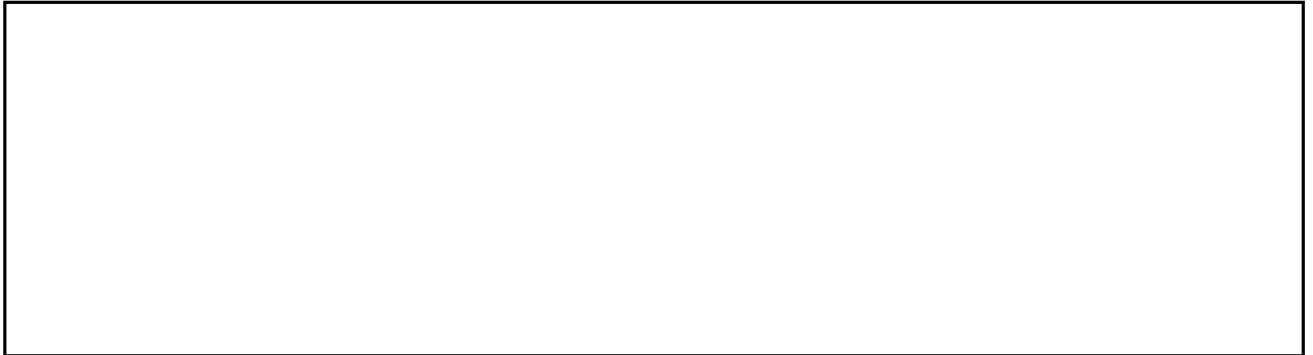


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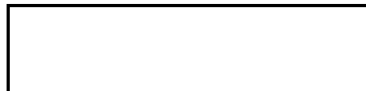
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CHANGE DETECTOR

OPERATION MANUAL

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SECTION I - INTRODUCTION

This manual has been prepared to acquaint the Change Detector operator with the operational features of the Change Detector Evaluation Model. A brief description of the system operation is included in order to give more meaning to the description of the operational controls. All of the controls necessary for operation of the system are described in detail. A list of pertinent operational specifications is presented in order to show the system capabilities and limitations. Finally, a recommended set-up and operating procedure is presented to enable the operator to proceed logically from the point where the films are inserted, through the registration process to the detection of changes. No attempt has been made to emphasize the advantages of one method of change detection available in the system over another since this is left to the operator's discretion.

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SECTION II - SYSTEM DESCRIPTION

A. GENERAL

The change detector is a device that will manually or automatically register two photographic images and display any differences or changes between the two images. After insertion of the two films, and an identification of the areas of comparative coverage a manual alignment of the two film images must be accomplished to obtain a coarse registration. Once this coarse registration is obtained, the display system may be activated to view gross changes requiring less registration accuracy, or the automatic registration system may be activated to obtain the fine degree of alignment required to detect changes of a higher order of resolution. Upon completion of the registration process the changes or difference between the two photographs are displayed on two display monitors. Various techniques for change enhancement and minimization of unwanted change are available when desired. Position readouts of the observed changes can then be accomplished.

STATINTL B. MANUAL REGISTRATION

Registration of the two photographic images may require up to six degrees of freedom. Translational displacement (X and Y) of one image relative to the other is necessary since it is unlikely that the center of the two photographs will have an identical geographic location. The rotation of one image relative to the other is necessary to compensate for differences in azimuth. The magnification of one image relative to the other must be adjustable to compensate for differences in scale factor due to variations in camera focal lengths and altitude. Unless highly stabilized camera mounts were employed to obtain the imagery, tip and tilt corrections are also necessary to complete the registration process.

These six degrees of registration freedom are available in the manual registration controls. With an image of each photograph displayed on its respective monitor, a manual alignment of the azimuth difference of the two photographs should be accomplished first since this is the most easily recognized registration error. The translational corrections and scale factor alignment should then be performed. If the tip and tilt errors are known, their corrections can also be inserted at this time. If only a coarse registration is desired, the change detection function can be activated and the changes observed on the monitor displays. When a finer degree of registration is desired the automatic registration system should be activated.

C. AUTOMATIC REGISTRATION

With the activation of the automatic registration system, the scanning displays are made inoperable and an area correlation of the two photographs is performed automatically. A backlight is activated behind one of the films and the resultant scene is imaged on the other film. The light transmitted through the second film is a measure of the correlation of the two films and is focused on a phototube which generates the electronic correlation signals. If both films are of the same polarity, i.e. both positives or both negatives, a maximum of transmitted light will result when the two films are perfectly correlated. The sequence of operations to obtain an automatic registration of the two films is as follows: an X and Y search and lock-on is performed to get within the dynamic lock-on range of the correlation function; the dynamic lock-on or nutation system is activated and the X and Y displacement errors are eliminated by a translation of the X,Y registration mechanism which moves the image of one film across the other until the error signal is at null. Similarly, azimuth and scale factor errors are eliminated by sensing the errors generated by the nutation process and driving the azimuth and

scale factor correction mechanisms until the error signals are nulled.

D. READOUT

Upon completion of the automatic registration function the system is programmed to proceed automatically to the readout mode. The following methods for change detection are available in the system:

1. Side-by-side comparison - each film image displayed on a monitor.
2. Flicker change detection - each film image alternately displayed on a single monitor at a low frequency rate.
3. Video difference change detection - a subtraction of the two film images, either right minus left or left minus right.
4. Video difference cloud and shadow rejection - the video difference technique with added circuitry to minimize the effect of undesirable shadow and cloud changes on the change display.
5. Video difference change enhance - a rapid method for determining the existence of changes by displaying all changes in one polarity (white) against a background which may be completely blanked out when desired.

In addition, to fully utilize the resolution capability of the system, an area of interest may be selected and a blow-up of the area made for a detailed inspection. Cross-hairs located at each film plane enable the operator to locate the areas of interest. Readout indicators which correspond to the cross-hair positions permit position recording of the areas of interest.

SECTION III - OPERATIONAL CONTROLS

With the exception of the film loading switches, all controls necessary to operate the change detector are located on the control panel which is shown in Figure 1. Controls associated with the right film and right display monitor are generally located on the right side of the control panel and those associated with the left film and monitor are located on the left side of the panel.

The POWER-ON switch located in the upper right corner of the control panel controls the complete system power. Approximately 1 minute and 30 seconds are required after this switch is activated before full power is applied to the system.

The film polarity switches, LEFT FILM POS-NEG and RIGHT FILM POS-NEG provide the proper display polarity on the respective display monitors. To obtain the best grey scale reproduction of the input films these switches should be set to the position corresponding to the polarity of the input films, i.e. POS for film positives and NEG for film negatives.

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Film motion is accomplished by activating the controls associated with the RIGHT FILM ADVANCE controls and LEFT FILM ADVANCE controls. Both control groups contain a SLOW-FAST switch which enables two basic film speeds to be employed, a slow speed for film positioning and a fast speed for film slewing. A vernier control on each of the speed ranges plus film direction control is provided by the REV - FWD lever arm. Film speed is proportional to the displacement of the REV - FWD lever arm which is spring loaded to return to the center or stop position when pressure is released.

Manual registration of the two images can be accomplished by pushing the MANUAL register switch. This activates the RIGHT FILM MANUAL

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ALIGNMENT and LEFT FILM MANUAL ALIGNMENT control groups. The RIGHT FILM MANUAL ALIGNMENT control group contains a "Y" CONTROL which permits vertical adjustment of the right film image, an "X" CONTROL which permits lateral adjustment of the right film image; and a ROTATION CONTROL which rotates the right film image for manual adjustment of azimuth errors between the two film images. The LEFT FILM MANUAL ALIGNMENT control group contains a "Y" CONTROL and "X" CONTROL which permit vertical and horizontal adjustment of the left film image, and the SCALE CONTROL which provides a scale factor correction capability between the two images. Additional manual registration capability is provided by the LEFT FILM - TIP and RIGHT FILM - TILT controls located on the left side of the control panel. These controls provide a limited degree of correction for film images containing tip and tilt distortions. The LEFT FILM - TIP control provides correction about an axis centered in the left film aperture which is parallel to the vertical dimension of the left film. The RIGHT FILM - TILT control provides a correction about an axis centered in the right film aperture which is parallel to the horizontal dimension of the right film.

Automatic registration of the two images is achieved by activating the AUTO registration switch located in the lower right center of the control panel. Approximately 80 seconds is required for the automatic registration sequence. Activation of the AUTO register switch deactivates the manual registration controls except for the two tip and tilt controls. Completion of the automatic registration sequence is indicated when the AUTO register switch button disengages and the indicator light goes out. The two SCALE CORRECTION lights CCW and CW give an indication that the scale factor adjustment servos have been moved from the position set manually by the automatic registration process. If further manual scale factor correction is determined to be necessary after automatic registration has taken place, the SCALE FACTOR control should be rotated in the direction indicated until the light goes out. This must be done prior to reactivation of the MANUAL registration switch to prevent the scale factor servos

from returning to the position that was originally set in manually; thus losing the benefit gained by the automatic registration. The ROTATION CORRECTION lights, CCW and CW operate in the same manner as the SCALE CORRECTION lights. If, after automatic registration, further manual adjustment of the rotational displacement between the two images is desired, the ROTATION CONTROL should be moved in the direction indicated by the light.

The displays available on the left monitor are controlled by the group of five switches located on the left center of the panel. These include: LEFT FILM, RIGHT FILM, FLICKER (alternate display of left and right film images), VIDEO DIFF, L-R (left film minus right film), and VIDEO DIFF, R-L (right film minus left film). The FLICKER RATE control located above the FLICKER switch allows adjustment of the rate at which the two images are presented on the left monitor in the flicker mode. The two CONTRAST controls for the LEFT FILM and RIGHT FILM are located above the two video difference switches. The system normally employs automatic contrast control circuitry to provide a constant contrast display for both the left film image and the right film image regardless of the film contrasts. The LEFT FILM and RIGHT FILM CONTRAST controls are normally used as vernier controls to adjust for slight differences in contrast left by the automatic contrast control system. For those cases where the range of the CONTRAST controls is not sufficient, two toggle switches labeled AUTO-MANUAL have been provided on the front of the control panel. When the switches are in the AUTO position the automatic contrast circuitry is operative. The MANUAL position permits full contrast variation on the CONTRAST controls.

The display presented on the right monitor is controlled by the following switches: LEFT FILM, RIGHT FILM, SHADOW REJECT, CLOUD REJECT, and CHANGE ENHANCE. The latter three switches may be operated individually or in any combination to provide the maximum capability for rejection of undesired changes. Activation of either the LEFT FILM or RIGHT FILM switch is required to disengage any of the other three switches.

The operation of the shadow and cloud rejection circuitry is based on the criterion that shadows will be the darkest areas of an image and clouds the lightest (assuming positive films). Changes attributed to shadows and clouds which appear on the video difference display can be detected and returned to a neutral grey contrast level by the shadow and cloud rejection circuitry. The level at which the shadow and cloud changes are detected and rejected is determined by the SHADOW REJECT LEVEL and CLOUD REJECT LEVEL controls. The CHANGE ENHANCE display presents all changes between the two sets of imagery as light areas against a dark background. The CHANGE ENHANCE BACKGROUND control allows the background level to be varied from a point where all of the changes are presented to a point where only the highest contrast changes are presented.

Any area of both of the film images within the film apertures may be selected and magnified through the use of the AREA SELECTION joystick and the MAGNIFICATION INCREASE-DECREASE switches. A movement of the joystick toward the display monitors results in a display of the upper portion of the film images. Similarly, a right hand movement of the joystick results in a display of the right side of the film images. Simultaneous rotation of both film images to provide viewing from any orientation is available by rotating the ORIENTATION OF BOTH IMAGES control.

Cross hairs located at each film plane are controlled by the RIGHT FILM CROSS-HAIR joystick and LEFT FILM CROSS-HAIR joystick. Cross-hair position measurements may be obtained from X and Y CROSS-HAIR POSITION meters adjacent to each joystick. The meters read directly in centimeters. A zero reading on all the meters indicates that the cross hairs are centered in the film apertures.

Three focus controls are available in the system. The LEFT LENS FOCUS and RIGHT LENS FOCUS controls are used to adjust the optical focus of the system. The FILM CRT FOCUS control is used to adjust the electronic focus of the scanning cathode ray tube light source. The focus

controls should be set after the MAGNIFICATION INCREASE switch has set the magnification to near maximum in order to obtain maximum focus sensitivity. After the system has been allowed to warm-up to its normal operating temperature, further adjustment of these controls is not normally necessary.

Any of four preset frame lengths may be counted by utilizing the FRAME LENGTH SELECTOR switch and FRAME COUNTER associated with each film. In addition, any frame number series may be set into the FRAME COUNTER by rotating the SET control. Films whose frame lengths are not the same may be inserted in the respective film magazines with no loss in counting accuracy. When films having frame lengths longer than the 70 millimeter film aperture width are inserted the FRAME POSITION INDICATOR may be used to measure the distance the film has traveled from a reference point to the area of interest within the viewing aperture. These indicators which read directly in millimeters, when used in conjunction with the cross hairs, allow an area of interest to be measured directly with respect to a reference point. Due to the counting rate limitation of the indicators they only operate when the film advance speed switches are in the SLOW position.

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SECTION IV - OPERATIONAL SPECIFICATIONS

The following table lists the specifications which are pertinent to the operation of the system:

Film Input Data

Film	70-mm roll, 250 ft max
Film Aperture Size	70-mm x 70-mm
Film Speed	
Slow Mode	0 - .2 inches/sec
Fast Mode	0 - 24 inches/sec
Frame Counter Accuracy	
Position No. 1 (2.3) in	≤ 5 frames for 250 ft of film
2 (10.45) in	≤ 1 " " " " "
3 (30) in	≤ 1 " " " " "
4 (30.7) in	≤ 1 " " " " "

Image Registration

Manual X Registration	± 50 percent of aperture for both left and right controls
Manual Y Registration	± 50 percent of aperture for both left and right controls
Manual Rotation	± 180 degrees
Manual Scale Factor	2X
Tip	± 5 degrees
Tilt	+5, -3 degrees
Automatic Registration Time	80 sec

Display Data

Film to Monitor Magnification	5X
Magnification Control Range	40X
Resolution	
Minimum Magnification	Approx. 6 line pairs/mm
Maximum Magnification	Approx. 30 line pairs/mm
Flicker Rate	1/2 to 6 cycles/sec
Cross-Hair Position Accuracy	± 5 percent of film aperture

SECTION V - RECOMMENDED OPERATING PROCEDURE

The operating procedure outlined below is intended to provide a logical sequence of operations starting with the initial equipment set-up and proceeding through the manual and automatic registration process for aligning the two sets of comparative imagery which results in displays of the changes that are suitable for analysis. Initial set-up of the system is accomplished as follows:

Activate POWER-ON switch. Allow approximately 1 minute for all power supplies to come on.

Set LEFT FILM POS NEG and RIGHT FILM POS-NEG switches according to film polarities to be used.

Set LOAD-OPERATE switches located on film magazines to LOAD position.

Insert films as shown in diagram of Figure 2.

Return switches to OPERATE position and close doors on registration compartment.

Select proper frame length position on each FRAME LENGTH SELECTOR.

Push RESET on FRAME COUNTERS.

Using SET control insert initial frame number into FRAME COUNTERS.

Center AREA SELECTION, LEFT and RIGHT CROSS-HAIR joysticks.

Activate LEFT FILM switch on left monitor and RIGHT FILM switch on right monitor.

Set contrast control switches to AUTO and adjust LEFT FILM and RIGHT FILM contrast controls to mid-range.

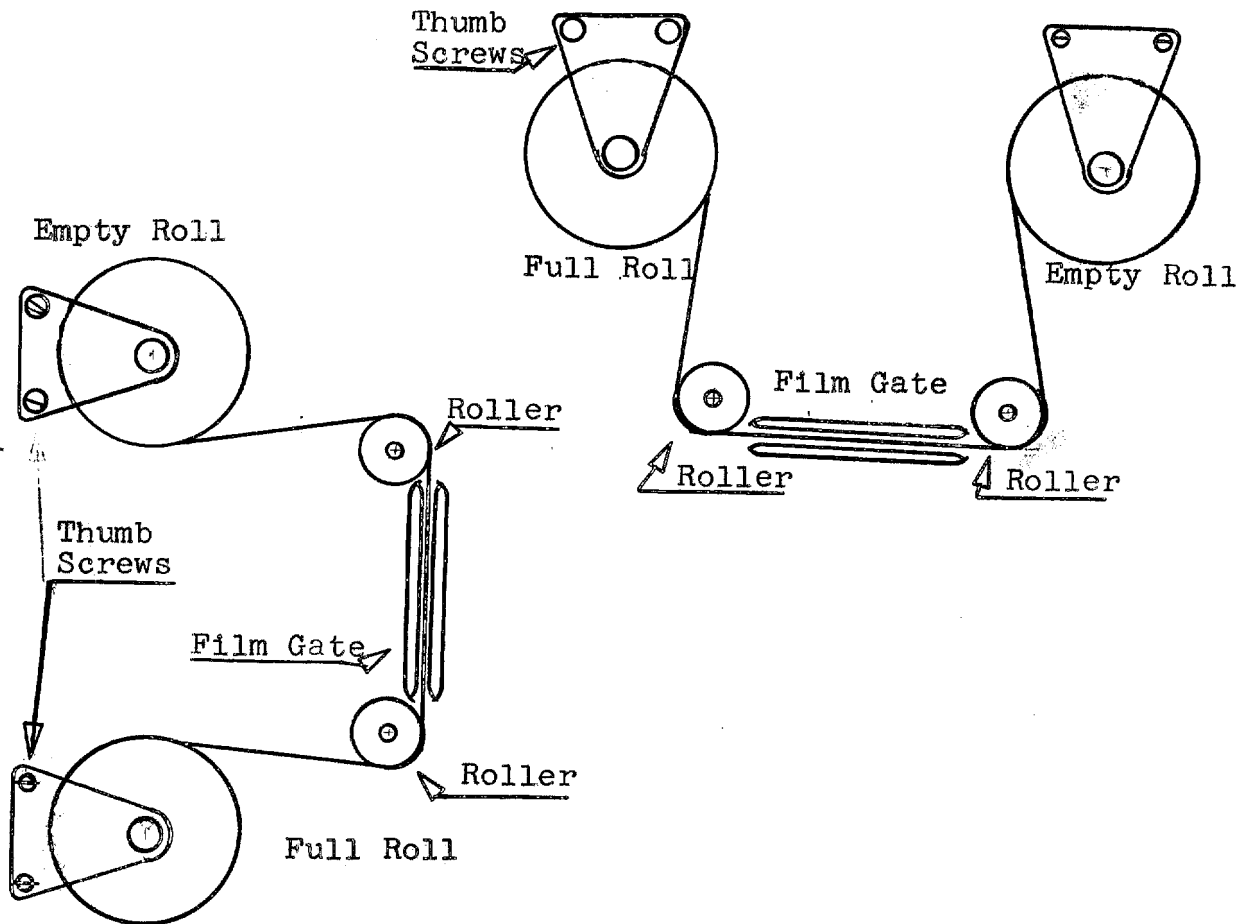


Figure 2. Film Loading Diagram

Move LEFT FILM ADVANCE FWD to obtain image display on left monitor.

Adjust ORIENTATION OF BOTH IMAGES control for horizontal display on left monitor.

Move RIGHT FILM ADVANCE FWD to obtain image display on right monitor.

Activate MAGNIFICATION INCREASE switch and hold until magnification reaches near maximum.

Adjust FILM CRT FOCUS and observe best image focus on either monitor.

Adjust LEFT LENS FOCUS, observe on left monitor.

Adjust RIGHT LENS FOCUS, observe on right monitor. Further adjustment of these controls is not normally necessary after the system has warmed up.

Return MAGNIFICATION DECREASE to minimum magnification.

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With all controls set as previously stated the process of identifying overlapping areas on the two sets of imagery and positioning the respective areas within the film apertures may proceed.

Depress MANUAL REGISTRATION switch and observe cross-hair position and rotation on right monitor.

Adjust ROTATION, X and Y controls of the RIGHT FILM MANUAL ALIGNMENT control group to center the cross hairs.

Observe and center the cross hairs on the left monitor using only the X and Y controls of the LEFT FILM MANUAL ALIGNMENT control group.

The centers of the film apertures should now be aligned in the center of their respective display monitors.

Set FILM ADVANCE switches to FAST and activate the REV-FWD FILM ADVANCE controls.

Identification of the areas of interest on each film roll may be accomplished by utilizing the frame counters if the frame number is known, or by observation of the images appearing on two display monitors. When the two overlapping areas of interest have been identified the FILM ADVANCE switches should be set to the SLOW position. If a frame length longer than the 70 millimeter aperture is being used, the reference point on the frame should be set over the cross hair and the RESET and SET buttons on the FRAME POSITION INDICATOR depressed. The reading on the FRAME POSITION INDICATOR can then be added to the reading of the X CROSS-HAIR POSITION meter when measuring positions within the area of interest. By manipulating the REV-FWD controls of the film advances, center the horizontal overlap area of the two images in the center of the respective displays. Manual registration of the two images proceeds as follows:

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Set the left monitor display to either of the VIDEO DIFF modes and the right monitor display to CHANGE ENHANCE.

Observe either or both monitors and adjust ROTATION CONTROL for minimum azimuth error.

Adjust RIGHT FILM MANUAL X and Y controls alternately with LEFT FILM MANUAL X and Y controls to obtain minimum X and Y errors between the images while keeping the center of the overlap area centered within the displays.

Adjust SCALE CONTROL for minimum scale difference between the two images.

If the tip and tilt errors are known for the film images they may be

inserted into the TIP and TILT controls at this time. If these errors are not known the TIP and TILT controls should be set to zero since the position of these controls may adversely affect the automatic registration process.

Following the manual registration process the AUTO REGISTRATION switch may be activated. Approximately 80 seconds is required to perform automatic registration of the two images. The end of the automatic registration cycle is indicated by a disengagement of the AUTO switch and dimming of the switch lamp.

The registered images may be received at this time by activating either the VIDEO DIFF switches or the FLICKER switch on the left monitor control and the CHANGE ENHANCE switch on the right monitor control.

Adjust either CONTRAST control for best correlation in the video difference mode or for identical contrast in the flicker mode. The FLICKER RATE control may be adjusted for optimum flicker frequency.

If it is determined that further registration is necessary a manual vernier adjustment may be performed as follows:

Adjust SCALE CONTROL and ROTATION CONTROL in the direction indicated by their respective correction lights until the lights are extinguished.

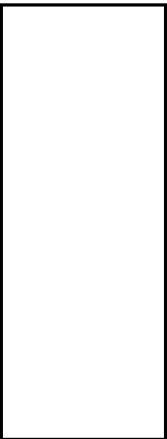
Activate the MANUAL REGISTRATION switch and proceed with manual adjustment of registration controls.

Often when a large degree of misregistration has been left after the initial manual registration has been performed, a residual error remains after the automatic cycle. This error can be minimized by depressing the AUTO register switch a second time and allowing the system to complete another automatic cycle.

The methods of change detection available to each display monitor

have been explained previously. The switches controlling these methods are self-explanatory. The AREA SELECTION joystick together with the MAGNIFICATION switches permit any area within the film apertures to be analyzed in detail. Both images may be rotated simultaneously by using the ORIENTATION OF BOTH IMAGES control. The use of the cross hairs and cross-hair position meters for location of position of changes is not dependent on the AREA SELECTION joystick position or the amount of magnification since the cross hairs are located at the film planes. The meters read directly in centimeters with zero indicating the center of the film aperture.

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